35th LEEDS-LYON SYMPOSIUM ON TRIBOLOGY

Surface interactions and tribochemistry in boundary lubrication of hypereutectic Al-Si alloys

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1.- INTRODUCTION

Al-Si alloys are characterized with a range of properties which make them potential materials to substitute cast iron in automotive engines. The formation of polyphosphate films on Al-Si alloys would indicate the potential use of ZDDP in lubrication of these alloys and hence facilitate their use as replacement materials for cast iron. It has been shown that the addition of MoDTC assists ZDDP to reduce friction and wear of hypereutectic Al-Si alloys. The aim of the current work is to fully characterize these two different kinds of tribofilms formed on the Al-Si alloy, showing the different surface interactions as a function of the presence of MoDTC in the tribofilm formation, as well as the different distribution and mechanical properties of the tribofilm.

2.- EXPERIMENTAL

Lubricants		
Base Oil	Bal.	Bal.
Ester	10%	10%
ZDDP	0.8%	0.8%
MoDTC	--	1.2%

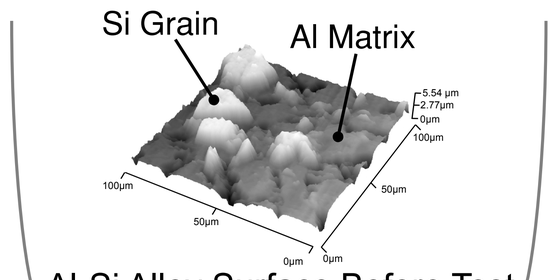
Test Materials	
Pins	AISI 52100 steel
Plates	Hypereutectic Al-Si alloy

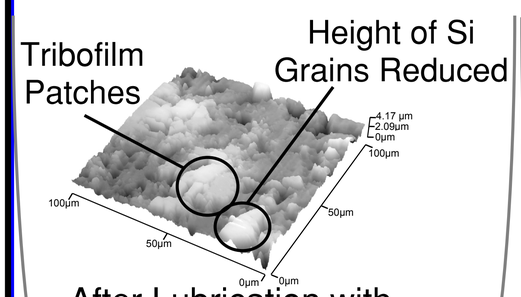
Test Conditions	
Normal Load	7 N
Max. Contact Pressure	152 MPa
Average Linear Speed	0.2 m/s
Test Duration	3 h
Temperature	100 ºC
TE 77 Tribometer	

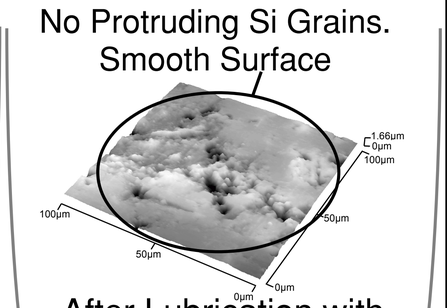
Technique	Use for
AFM Topometrix EXPLORER™	Morphology and Topography
Hitachi S3500N SEM and EDX	Surface Chemical Analysis
Millibrook miniSIMS	
FEI Nova 200 NanoLab SEM/FIB	Tribofilm Cross Section
Nanotest System	Mechanical Properties

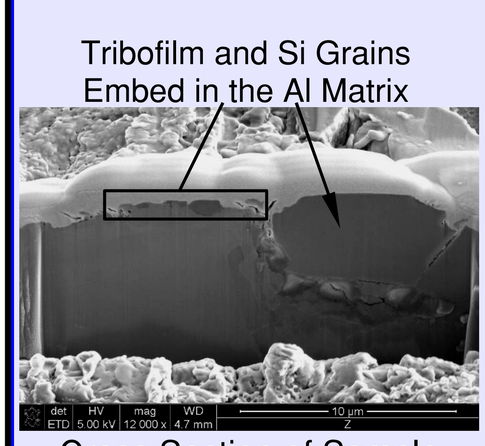
3.- RESULTS AND DISCUSSION

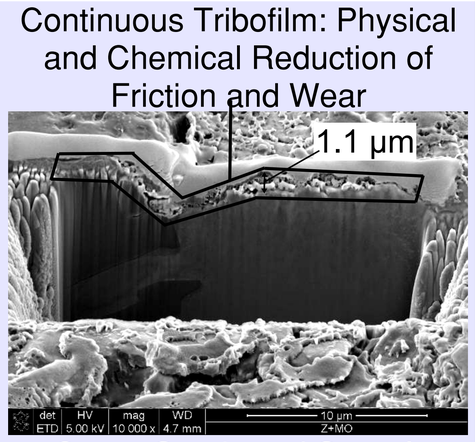
3.1.- TOPOGRAPHY



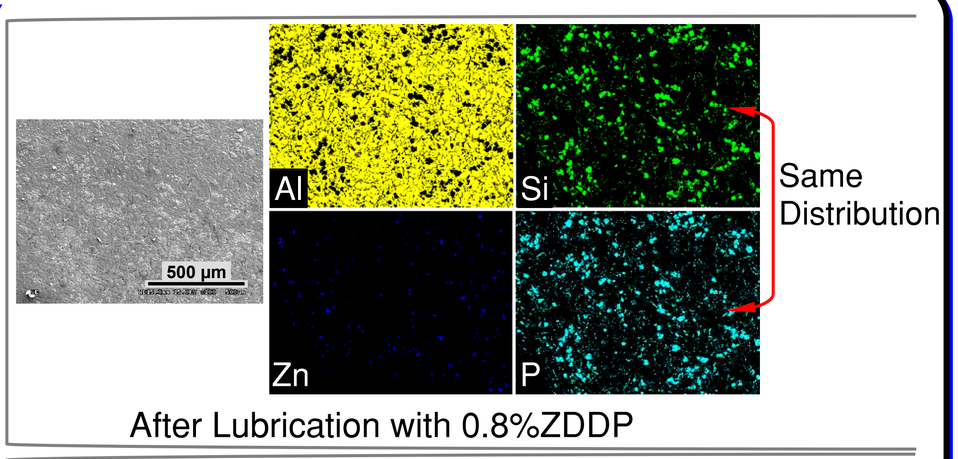


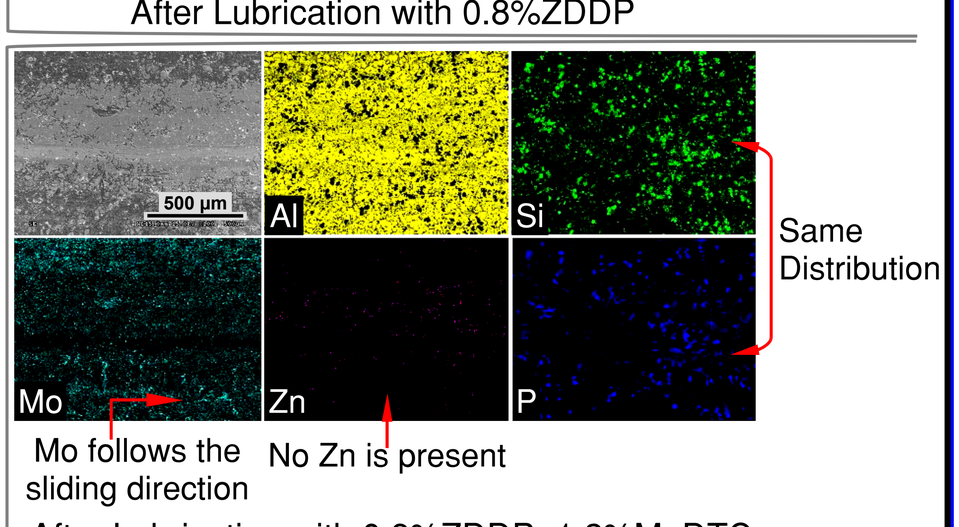




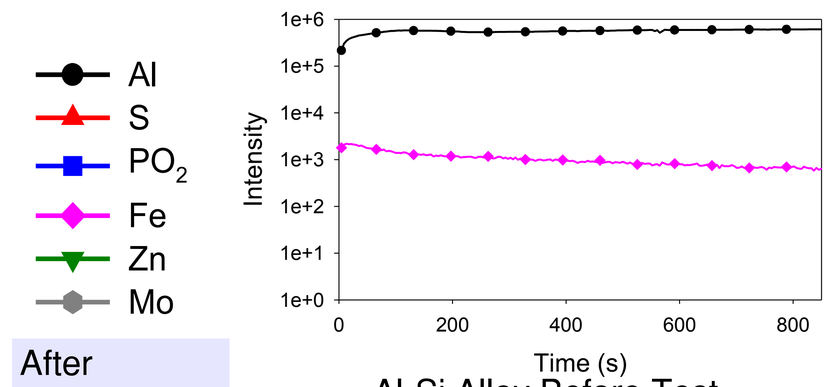


3.2.- SEM AND EDS ELEMENT MAPPING



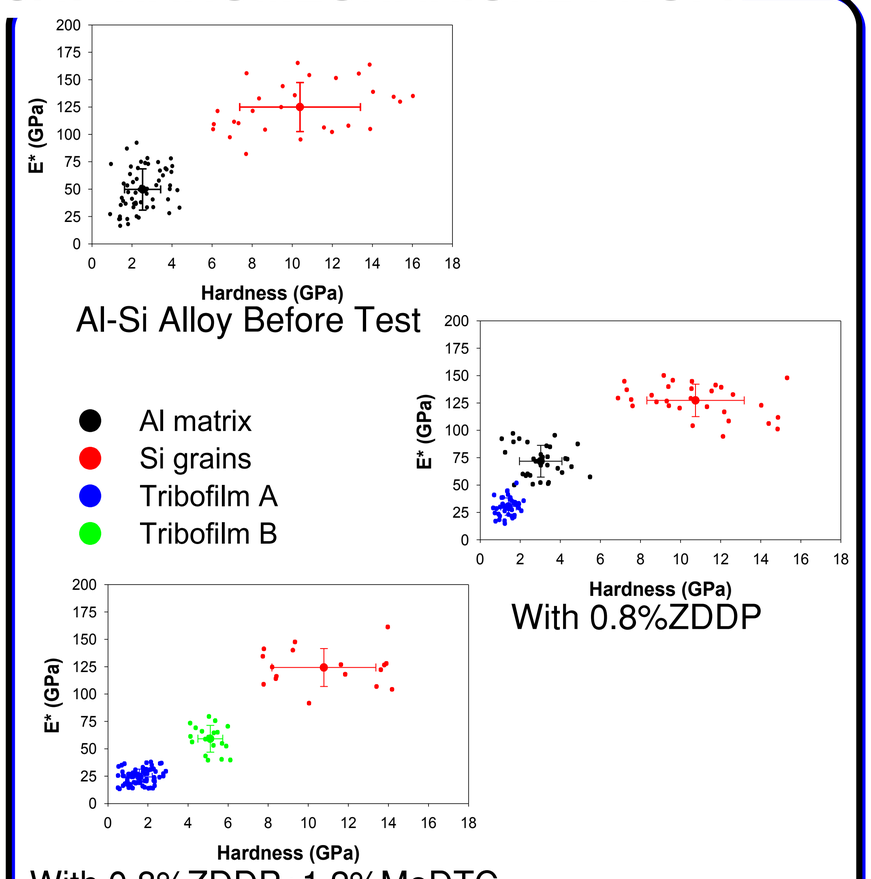


3.3.- miniSIMS DEPTH PROFILES



After lubrication with 0.8%ZDDP, the tribofilm is rich in Fe and Zn, PO_2 and S reach their maximum several layers below the surface. When adding 1.2%MoDTC Zn, PO_2 and S reach the maximum on the outer surface layer of the samples.

3.4.- NANOMECHANICAL PROP.



4.- CONCLUSIONS AND ACKNOWLEDGEMENTS

✗ With only ZDDP, a decrease of the height of the Si grains can be observed. FIB cross section shows a tribofilm containing Si particles embed into the Al matrix, due to the higher hardness of the Si particles.
✗ The addition of MoDTC gives a smoother surface on the Al-Si sample. FIB cross sections shows a tribofilm covering the whole alloy surface, reducing physically and chemically the friction and wear.
✗ When using 0.8%ZDDP, the top layer is mainly composed of Fe, Zn, and a mixture of sulphides and phosphates. When adding MoDTC, this top layer is mainly formed of phosphates and sulphides.
✗ Nanoindentations results from the 0.8%ZDDP+1.2%MoDTC lubricated samples show the presence of two tribofilms, harder and softer than the Al matrix respectively.

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